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Seed Germination and Seedling Establishment of Phreatophyte Species

by

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SEED GERMINATION AND SEEDLING ESTABLISHMENT OF PHREATOPHYTE SPECIES

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by

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Rocky Mountain Forest and Range Experiment Station1/

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1/ Central headquarters maintained in cooperation with Colorado State University at Fort Collins; research reported here was conducted in cooperation with the University of Arizona at Tucson and Arizona State University at Tempe.

SEED GERMINATION AND SEEDLING ESTABLISHMENT OF PHREATOPHYTE SPECIES

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The demands for water, which have increased so rapidly in the Southwest in recent years, make it imperative to fully utilize and to improve all local supplies. This growing demand has lead to widespread interest in certain water-wasting plants called phreatophytes.

Some phreatophytes growing along channels and flood plains appear to be more wasteful of water than others.[2/] For example, five-stamen tamarisk (Tamarix pentandra Pall.) is reputedly a heavy user of water. Following its introduction from the Old World, this species spread rapidly throughout the Southwest.[3/] Much effort has been expended to control tamarisk. More knowledge of the ecological factors influencing spread of this and other species is needed for efficient control.

The U. S. Forest Service recently began a research project to develop better management methods for flood plain and streambank vegetation. One phase of the project deals with seed germination and seedling establishment of the important tree and shrub species growing in these moist sites, particularly tamarisk.

Tamarisk, cottonwood (Populus spp.), willow (Salix spp.), seepwillow (Baccharis glutinosa Pers.), broom baccharis (B. sarothroides A. Gray), and arrowweed (Pluchea sericea (Nutt.) Coville) are riparian species of the Southwest that produce windborne seeds in large quantities. The spread of individual species is influenced by viability of seed; rapidity of germination; response of seed to environmental factors such as moisture, temperature, and light; ability of seedlings to withstand drought and submergence; and the growth and development of seedlings. This paper evaluates some of these factors, particularly for tamarisk, and proposes action for the reduction of spread of undesirable species.

SEED GERMINATION

Ability of seed to germinate readily under a wide variety of conditions greatly favors the spread of any species. Hence, germination characteristics of phreatophyte species were studied under various storage conditions and different environmental influences in 1957 and 1958.

COLLECTION AND STORAGE OF SEED

Collections During 1957

Seed of phreatophyte species growing along the Salt River, east of Granite Reef Dam, were usually collected at biweekly intervals in 1957 (see table 1, Appendix). The first tamarisk seed was collected on April 12, 1957, and the last on September 30, 1957. Seed produced by this species was scarce during July and was produced intermittently thereafter. Seepwillow started producing seeds on March 11, 1957, ceased during the summer, and resumed seed production from September to October. Broom baccharis seed was collected in November 1957.

2/ Gatewood, J. S., Robinson, T. W., Colby, B. R., and others. Use of water by bottom-land vegetation in lower Safford Valley, Arizona. U. S. Geol. Survey Water-Supply Paper 1103, 210 pp., illus. 1950.

3/ Bowser, Curtis W. Symposium on phreatophytes: Introduction and spread of the undesirable tamarisks in the Pacific Southwestern section of the United States and comments concerning the plant's influence upon the indigenous vegetation. Presented at Amer. Geophys. Union, Pacific Southwest Region Mtg., Sacramento, Calif., Feb. 1957. Phreatophyte Subcom. of Pacific Southwest Interagency Com. pp. 12-17. 1958.

The 1957 seed lots were stored in the laboratory at temperatures between 75°F. and 80°F. except that half of the seeds in 4 late-season lots of tamarisk and 5 of seepwillow were stored in a refrigerator at 40°F.

Collections During 1958

Seed of the principal phreatophyte species on the Salt River were collected weekly whenever available in 1958. The first collection of tamarisk was made April 21, 1958, and the last on October 6. Seeds were not available on several occasions in the summer because of rains or temporary cessation of flowering. Seed was most abundant during the spring period.

Seepwillow seeds were collected in the spring from March 31 to May 26. The fall collections started September 8 and lasted until November 10. No seeds were available from June to August.

Ripe cottonwood seeds were available only during April. Arrowweed seeds were collected on May 26, July 7, and July 14, 1958.

All tamarisk seed lots (except for a small lot collected May 5) were divided in half: one portion was stored in the greenhouse at temperatures similar to open air and the other portion stored in the laboratory. Seed of the other species were stored only in the laboratory.

PROCEDURE

All germination studies were made by sowing seed in petri dishes on moist filter paper. Usually seeds were sown in the afternoon and examined each subsequent day until germination ceased. Only seeds that appeared firm at 13 magnifications were counted in the viability tally.

In 1957, seed were usually sown the day after collection and at 1- or 2-week intervals thereafter for the first several months. When the viability of the seed became zero or gave consistent germination percentages, the interval between tests was usually increased to 4 weeks. After the seed was about a year old, the interval was increased to 3 months. All seed lots continue to be tested until exhausted, even though viability is zero. The same procedure has been followed with early 1958 seed, except that all lots were tested at weekly intervals for the first several months.

Some variability in the early germination tests may have been caused by poor mixing of seed within lots. This did not become apparent until the fall of 1957. Thereafter, all lots (except cottonwood) were mixed by blowing a stream of air into a closed container; this separated the clusters without scarifying the seed.

SEED VIABILITY

Seed viability tests were designed to determine (1) whether phreatophyte seeds lose viability with age, and (2) whether storage in cold or hot temperatures affects viability.

Laboratory-stored Seed

Tamarisk seed stored in the laboratory lost its viability in a relatively short time. Seeds collected in the spring and early summer of 1957 lost most of their viability in 6 to 17 weeks (fig. 1; see table 2, Appendix). The April to July 1958 collections failed to germinate (except for an occasional seed) after 9 to 12 weeks

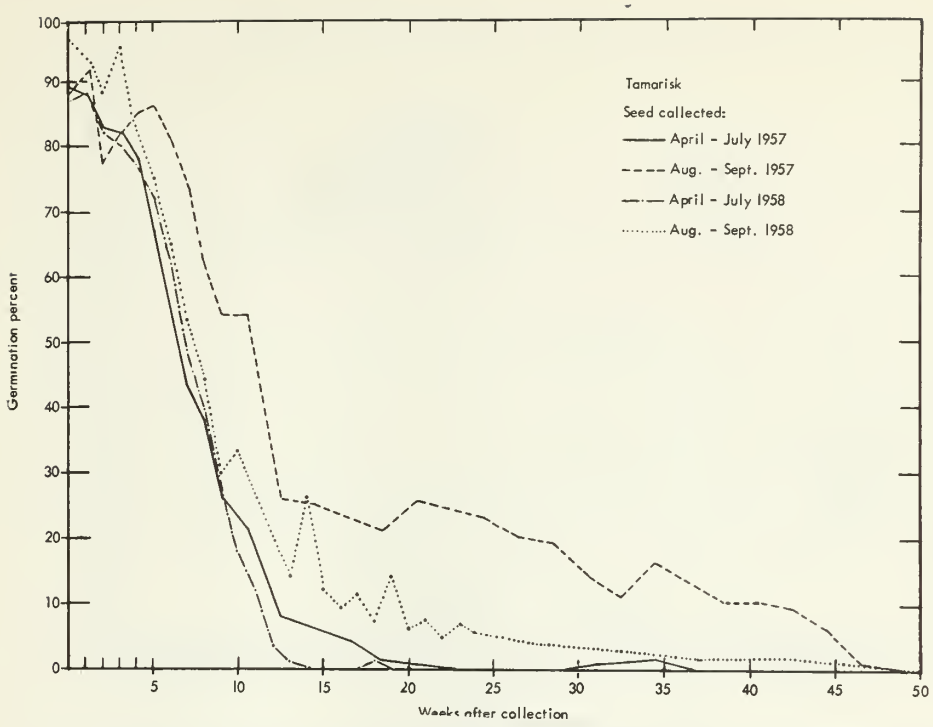

Figure 1. --Germination of five-stamen tamarisk seeds collected in different seasons.

in storage (fig. 1; see table 3, Appendix). Seed collected in the late summer and fall remained viable over the winter. However, few seed are produced during this period and therefore few viable seed would be available by the next growing season. One lot with unusually prolonged viability (45 weeks) collected in August 1957 held the average germination percent for this season considerably above the 1958 average.

Seepwillow gave lower initial germination than tamarisk. Few seed lots exceeded 50 percent germination (fig. 2; see table 4, Appendix). Secondly, germination was much more variable with time. For example, fall lots of 1957 averaged only 10 percent germination at 4 weeks, increased to 46 percent at 10 weeks, and fell sharply thereafter. Although variation in germination was not so marked in seed lots collected in other seasons (fig. 2), it does seem to be a characteristic of seepwillow (see tables 5 and 6, Appendix). Thirdly, seepwillow seeds remained viable longer than those of tamarisk. Seed viability still averaged more than 10 percent a year after collection but dropped to a very low figure thereafter.

Seed lots of broom baccharis were collected at the peak of the fruiting season in November of both 1957 and 1958 (see table 7, Appendix). Except for a comparatively low germination for the first 2 to 3 weeks, viability of 1957 seed remained high for 18 months. The 1958 seed approached 100-percent germination consistently.

Seed of Fremont cottonwood lost all viability in 7 weeks (see table 8, Appendix). In contrast, arrowweed seed remained viable throughout the period of test (see table 8, Appendix). Spring collections were more viable than summer collections.

In summary, seeds of tamarisk and cottonwood lose their viability rapidly, but seeds of seepwillow, broom baccharis, and arrowweed retain viability for more than a year.

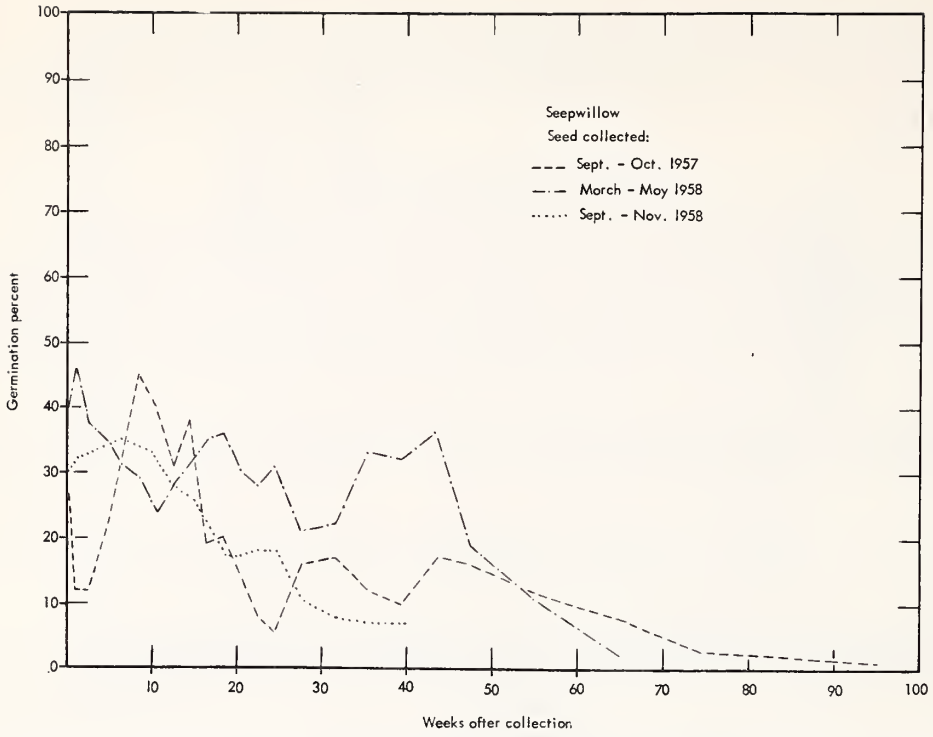

Figure 2.--Germination of seepwillow seeds collected in different seasons.

Effect of Cold Storage

Storage at low temperature generally prolongs the viability of seeds.[4] Recent studies on Populus deltoides[5] and on tamarisk[6] indicate that these species are not exceptions.

Viability of tamarisk and seepwillow were found to be prolonged by cold temperatures under the following conditions. Seed lots of tamarisk collected August 9, August 19, September 3, and September 30, 1957, were separated into two portions on October 1, 1957. One portion was stored in the laboratory at a room temperature averaging about 77°F., the other portion was placed in a refrigerator at 40°F. Thus, early lots had several weeks of warm temperatures in the laboratory while the last lot was placed in refrigeration on the day after collection. Three lots of seepwillow collected in September 1957 were divided into two parts on the day of collection. In both cases, one portion of the seed was stored in the laboratory and the other placed in the refrigerator.

Viability of both tamarisk and seepwillow seed was prolonged by cold storage (fig. 3; see table 9, Appendix). Seed lots of tamarisk stored at low temperatures declined slowly in viability during the test period. At 95 weeks more than half of the seed were still viable, whereas the laboratory-stored seed lost all viability in less than a year. Though seepwillow seed stored in cold temperatures showed consistently higher viability than the laboratory-stored seed, the difference between the two treatments was not striking until the seed was 1 year old. At this time, the cold-storage seed increased in germination percent, but laboratory seed began a marked decline.

4/ U. S. Forest Service. Woody-plant seed manual. U. S. Dept. Agr. Misc. Pub. 654, 416 pp., illus. 1948.

5/ McComb., A. L., and Lovestead, Howard S. Viability of cottonwood seeds in relation to storage temperatures and humidities. U. S. Forest Serv. Tree Planters' Notes 17: 9-11, illus. 1954. [Processed.]

6/ Merkel, Daniel L., and Hopkins, Harold H. Life history of saltcedar (Tamarix gallica L.). Kans. Acad. Sci. Trans. 60: 360-369. 1957.

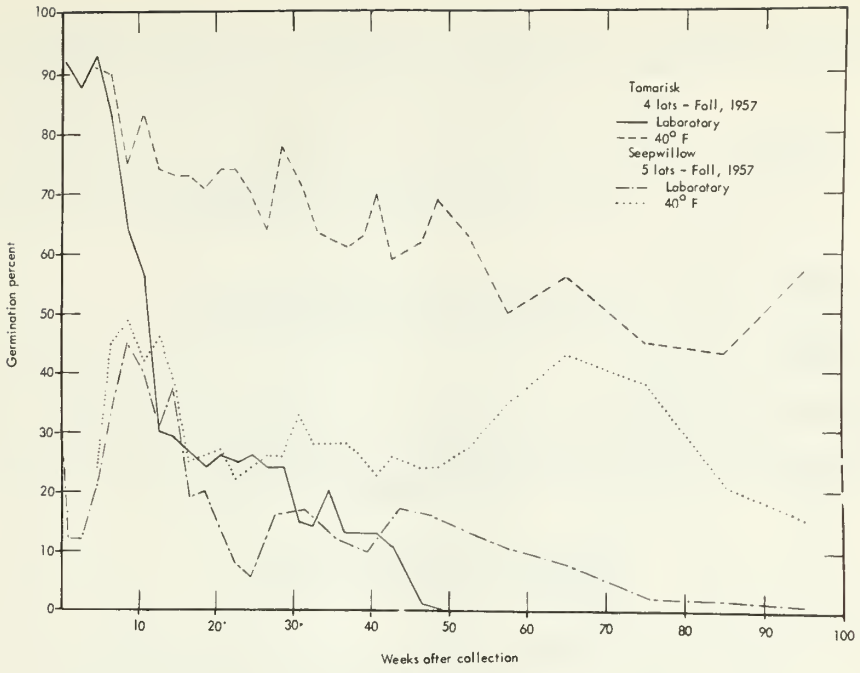

Figure 3. --Prolonged viability of seeds of tamarisk and seepwillow after storage in cool temperature.

Effect of Summer Heat

High temperatures decrease tamarisk seed viability as shown by the following test. All lots of tamarisk seed collected from April to August 1958 (except May 5) were separated into two portions; one-half stored in the laboratory and the other half stored in the greenhouse, where the seed were subjected to temperatures that rose almost daily to 100°F. These temperatures were comparable to those at the site where the seed were collected. Seed stored in the greenhouse lost its viability much sooner than seed stored in the laboratory (fig. 4; see table 10, Appendix).

FACTORS AFFECTING GERMINATION OF FRESH SEED

Moisture, temperature, and light influence germination of fresh seed. Several exploratory studies were made to determine the effect of these factors on tamarisk seed.

Moisture

Tamarisk seed germinates while floating on water. Many germinating seeds were observed on the water surface of the Salt River in the springs of 1957, 1958, and 1959. Moreover, early germination tests indicated that very moist conditions were needed for satisfactory germination.

To test the effect of moisture on germination, seeds were placed in petri dishes half full of silt loam at moisture contents varying from 8 to 28 percent. The 28 percent soil moisture was roughly at field saturation. Fresh tamarisk

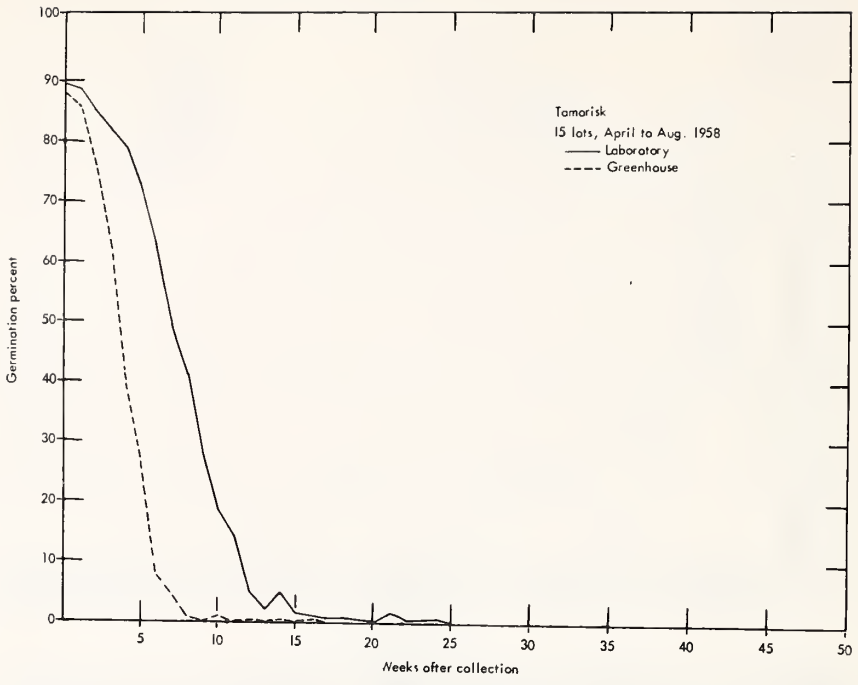

Figure 4. --Reduction of viability of tamarisk seeds after storage in hot temperatures.

seed, collected June 6, 1957, were sown in the petri dishes at 2:30 p.m. on June 11 (table 1). All dishes were covered after sowing the seed. Under the conditions of this test, the air in the dishes approached saturation and supplied enough moisture for seed germination.

Table 1. --Relation of tamarisk seed germination to soil moisture in closed petri dishes

Soil moisture percent	Seeds sown June 11, 1957 2:30 p.m.	Germination June 12 9:00 a.m.	June 13 9:00 a.m.	June 17 9:00 a.m.	Total
		Number of seeds			Percent
8	26	20	21	21	80.8
12	21	16	16	16	76.2
16	22	20	20	20	90.9
20	26	19	23	23	88.5
24	26	20	25	25	96.2
28	22	16	18	18	81.8

Starting on June 12, 1957, seed of the same seed lot were placed in open petri dishes half full of soil, maintained at about the same range of soil moistures (table 2). Covered dishes were also used as a check. After 2 days, the dishes were covered to prevent excessive drying over the weekend.

In the open dishes, seeds germinated on only the wet or moist soils. After covering, germination took place at all moisture levels.

Table 2. --Relation of tamarisk seed germination to soil moisture in both open and closed petri dishes

Soil moisture percent	Seeds sown June 12, 1957 2:30 p.m.	Germination					
		June 13 8:00 a.m.	June 13 4:00 p.m.	June 14[1] 2:30 p.m.	June 17 9:00 p.m.	June 14	June 17
		Number of seeds				Percent	
OPEN PETRI DISHES							
4.4	24	0	0	0	17	0	70.8
9.7	25	0	0	0	14	0	56.0
14.3	26	0	0	0	17	0	65.4
18.0	22	0	0	1	14	4.5	68.0
20.7	28	4	1	0	17	17.9	78.6
25.2	27	7	1	0	11	29.6	70.4
28.9	24	17	0	0	6	70.8	95.8
CLOSED PETRI DISHES							
4.4	25	0	3	8	3	44.0	56.0
12.2	25	21	0	0	0	84.0	84.0
24.0	26	20	2	0	0	84.6	84.6

[1] All dishes closed at this time.

Wetting seed for various periods and then drying (as would occur naturally in the field) affects germination. A seed lot collected July 19 was divided into 6 parts. These parts were soaked for 1 to 6 hours on July 30. Those soaked 6 hours were swollen and almost ready to emerge but seed coats were still unbroken. After the soaking, seeds were dried in an oven set at 40°C. for 3 to 4 hours. The seeds were sown in petri dishes on August 5 at 2:00 p.m. (table 3).

More than 2 hours of wetting, followed by drying, reduced germination percentage. Time required for germination was increased by 24 hours or more. The seedlings appearing in the groups soaked 2 to 6 hours were bright green, but were undersized, had no root hairs, and had dark root tips.

Table 3.--Effect of wetting and then drying upon germination of tamarisk seed

Hours soaked July 30, 1957	Seeds sown Aug. 5 2:00 p.m.	Germination					
		Aug. 6 8:00 a.m.	Aug. 6 3:15 p.m.	Aug. 7 8:30 a.m.	Aug. 7 3:30 p.m.	Aug. 8 8:00 a.m.	Total
		Number of seeds					Percent
Control	46	20	12	5	3	0	87.0
1	51	10	23	8	0	3	86.3
2	41	0	8	22	2	0	78.0
3	47	0	5	9	5	3	46.8
4	31	0	3	5	2	0	32.2
5	43	0	1	6	1	5	30.2
6	39	0	1	3	0	0	10.2

Heat

Temperatures above 100°C. are required to reduce viability of tamarisk seed. Seed collected June 28, 1957, were heated in an oven at various temperatures for 10 minutes on July 8. The same lot was used for a second test on July 15 but was heated for 20 minutes. Tamarisk seeds withstood a dry heat of 100° C. for this period. Higher temperatures killed all the seeds in a few minutes. The effect of oven heating on germination of tamarisk seed is as follows:

10 minutes		20 minutes	
Temperature (Degrees C.)	Germination (Percent)	Temperature (Degrees C.)	Germination (Percent)
40.0	98.0	45.0	89.1
65.5	100.0	76.0	77.0
93.0	84.9	100.0	76.0
--	--	110.0	0
121.0	0	126.0	0

Light

Different lots of tamarisk seeds sown in petri dishes were placed in darkness for several days. Germination equaled that of similar lots left in the light. Seedlings were the same size and had root hairs, but they were etiolated. When placed in the light they became green in several hours.

GROWTH AND DEVELOPMENT OF TAMARISK SEEDLINGS

Tamarisk seeds have abundant pappus hairs that form a column when moistened (fig. 5). In 5 to 8 hours after moistening, the embryo has usually swollen enough to break the seed coat. By 24 hours the seedling is free from the seed coat, the hypocotyl has turned downward, and a corona of root hairs has developed around the radicle to anchor the seedling. As the stem straightens, the cotyledons separate.

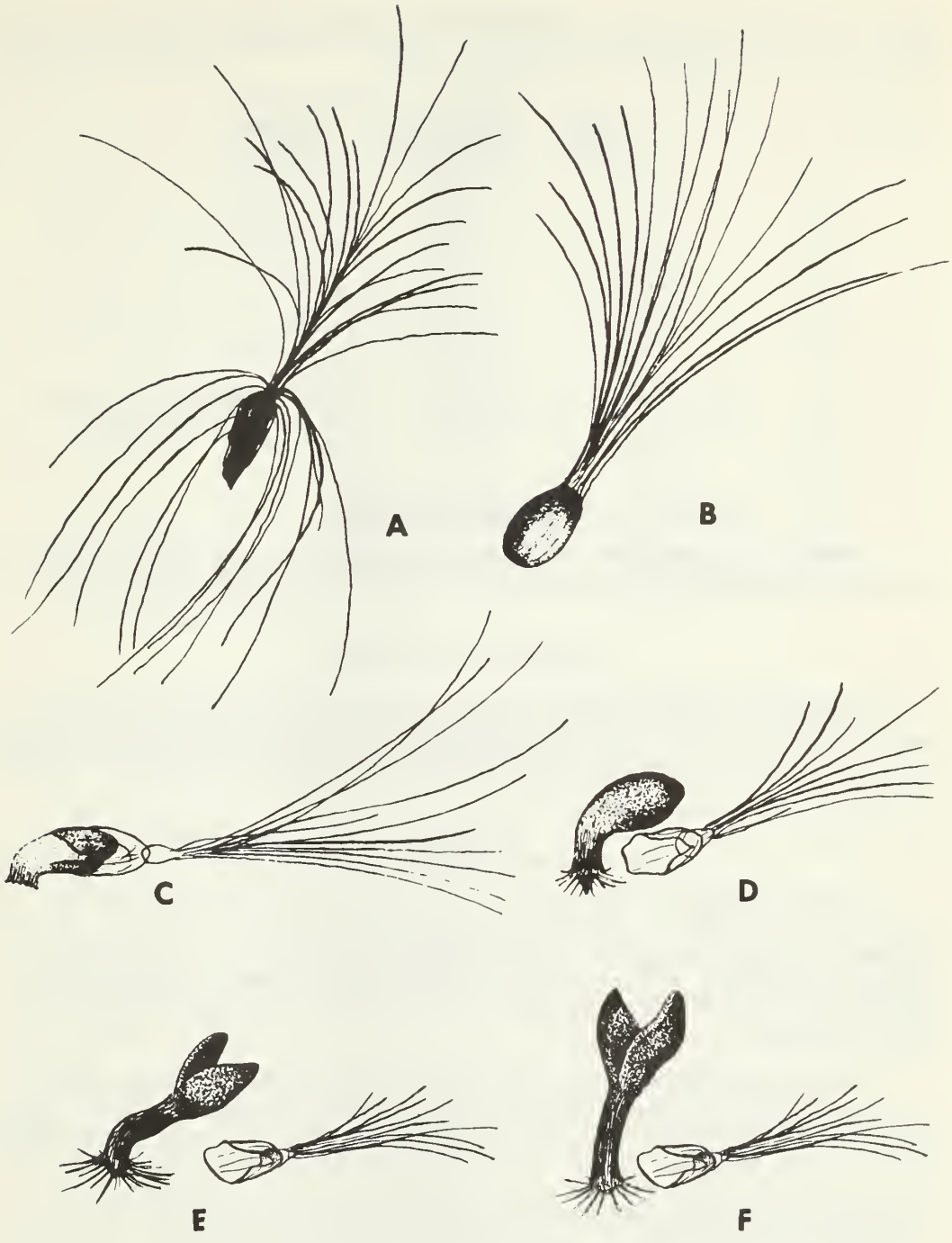

Figure 5. --Development of tamarisk seedling. A, Dry seed; B, Seed moistened several hours; C, Seedling 8 hours after moistening; D, Seedling 24 hours after moistening; E, Seedling 40 hours after moistening; F, Seedling 48 hours after moistening. (Drawings by Dennis C. Jackson.)

Tamarisk seedlings were grown in nine clay pots in the greenhouse during the summer of 1958 to determine root growth of developing seedlings. Seedlings were

thinned to 15 plants per pot upon germination and to 5 plants per pot at 5 weeks. When 2 weeks old, and weekly thereafter, a pot was chosen at random, and shoot and root growth were measured as shown below:

Age in weeks	Average shoot length (cm.)	Average root length (cm.)
2	0.5	1.5
3	1.2	2.8
4	1.9	4.0
5	3.2	5.1
6	6.6	6.3
7	7.9	10.2
8	11.7	15.6
9	10.7	Roots too entangled to
10	21.8	measure accurately

SEEDLING SURVIVAL

Studies have been made both in the laboratory and in the Salt River experimental area to determine the more important factors limiting seedling survival.

LABORATORY STUDIES

Survival of tamarisk and seepwillow seedlings were studied under varying periods of simulated drought and submergence. In addition, tamarisk seedlings were grown under several conditions of temperature and soil moisture.

Drought

Twenty seedlings of each species, averaging less than 1 inch in height, were transplanted on March 5, 1957, from the field to small pots. These seedlings were allowed to grow until April 26, 1957, when watering ceased. At that time they averaged less than 2 inches in height. By April 29, 6 of the 20 seepwillow were beginning to wilt and by the next day all were wilted. Tamarisk did not begin to wilt until May 1.

Five pots of each species were chosen at random and watered on May 2. Five more of each on May 4, five on May 6, and the remainder on May 8. Of the plants watered on May 2, three seepwillow and two tamarisk survived. No plants survived from the other groups. Thus, 60 percent of the five seepwillows withstood 2 days of wilting, but only 40 percent of the tamarisk withstood 1 day of drought. While this suggested that seepwillow could withstand more drying in the seedling stage than tamarisk, results were far from conclusive.

On April 3, 1957, two small seedlings of tamarisk and two of seepwillow were transplanted in each of four large pots in the greenhouse (table 4). Placing the species together in one pot assured that both were growing under similar soil moisture conditions.

Water was withheld on May 16 and the plants were moved into the laboratory. Average height of tamarisk was 28.4 cm., and seepwillow, 34.2 cm.

Table 4. --Survival of tamarisk and seepwillow seedlings under drought conditions

Pot No.	Species	Plant	Condition of plant					Days of drought
			May 21 3:30 p.m.	May 22 3:30 p.m.	May 23 4:20 p.m.	May 24 3:00 p.m.	June 6	
								Number
1	Tamarisk	1	Wilted[1]	Green	Green	Green	Green	1
		2	Wilted[1]	Green	Green	Green	Green	1
	Seepwillow	1	Wilted[1]	Green	Green	Green	Green	1
		2	Wilted[1]	Green	Green	Green	Green	1
2	Tamarisk	1	Wilted	50% dry[1]	50% dry	50% dry	Dead	2
		2	Wilted	50% dry[1]	50% dry	50% dry	Dead	2
	Seepwillow	1	Wilted	Tips dry[1]	Green	Green	Green	2
		2	Wilted	Tips dry[1]	Green	Green	Green	2
3	Tamarisk	1	Wilted	50% dry	Completely dry[1]	Completely dry	Dead	3
		2	Wilted	50% dry	Completely dry[1]	Completely dry	Dead	3
	Seepwillow	1	Wilted	Tips dry	50% dry[1]	Tips dry	Green	3
		2	Wilted	50% dry	50% dry[1]	Tips dry	Green	3
4	Tamarisk	1	Wilted	50% dry	Completely dry	Completely dry[1]	Dead	4
		2	Wilted	50% dry	Completely dry	Completely dry[1]	Dead	4
	Seepwillow	1	Wilted	50% dry	50% dry	50% dry[1]	Dead	4
		2	Wilted	50% dry	Completely dry	Completely dry[1]	Dead	4

[1] Pot watered and subsequently kept moist

On May 20, wilting was evident in all pots. The next day wilting was almost 100 percent. The first pot selected at random was watered in the afternoon of May 21 and the others on consecutive afternoons.

Again, seepwillow appeared to withstand longer periods of wilting than tamarisk. None of the tamarisk survived 2 days or more of drought; the seepwillows on the other hand withstood 3 days, but none survived 4 days.

Submergence

To determine how long tamarisk seeds will live under water, several tests of submergence effects were initiated in 1957. In preliminary tests, tiny 5-day-old and 10-day-old seedlings floated to the water surface because of insufficient roots to anchor the plants. Accordingly, 16 seedlings were grown singly in pots until they were 3 to 4 inches in height. They were submerged for periods of 4, 6, 12, and 24 days. Half of each lot were kept completely submerged and half were kept with 50 percent of the total height of the plant out of water.

Even the 24-day submergence did not kill the tamarisk plants, though many of the small branches turned yellow and died back. Some stems were killed by 12-day submergence. No bad effect was produced by 4 or 6 days of submergence. No difference in response was noted between plants completely and those 50 percent submerged.

In June 1958, seeds of tamarisk and seepwillow were sown in pots for a second study, with submergence varying from 1 to 6 weeks. Plants of various ages were used. Seedlings were thinned to one plant per pot. Table 5 indicates that 4 to 6 weeks will kill a majority of tamarisk seedlings, and a shorter period will kill seepwillow seedlings. The 12-week-old tamarisk appeared to survive submergence better than younger plants.

Table 5. --Survival of tamarisk and seepwillow seedlings after prolonged submergence

Age in weeks at time of submergence	Period of submergence			
	1 week	2 weeks	4 weeks	6 weeks
	Condition 4 weeks after removal from water			
Tamarisk				
4	Good	Good	Good	Dead
6	Good	Good	Fair	Dead
8	Good	Good	Dead	Dead
10	Good	Poor	Dead	Dead
12	Good	Good	Good	Good
Seepwillow				
4	Dead	Fair	Good	Dead
6	Good	Good	Dead	Dead
8	Good	Dead	Dead	Dead
10	Poor	Good	Dead	Dead
12	Dead	Dead	Dead	Dead

Temperature and Soil Moisture

Five seeds were sown on July 22, 1957, in each of eight clay pots containing silt soil. Four of the pots were kept in the laboratory (78°F. to 80°F.) and four in the greenhouse, where temperature exceeded 100°F. practically every day. At each location two pots were left standing continuously in trays with about half an inch of water, thus keeping the soil nearly saturated. The other two pots were watered daily by placing the pots in the trays for 4 hours. Half of the pots were watered with tap water and half with distilled water. Table 6 gives the growth in centimeters of the largest individual in each pot. Only those seedlings growing in saturated soil in the greenhouse made appreciable growth. Under these growing conditions those plants watered with distilled water made the best growth.

FIELD ESTABLISHMENT OF SEEDLINGS

Establishment of phreatophyte seedlings on bare soil was studied at two places on a flood plain of the Salt River east of Tempe, Arizona. At one place Bermudagrass sod was removed to leave bare soil. The other place was a bare gravel strip between the sodded banks and the flowing water.

Bermudagrass Plots

Bermudagrass cover was removed in March 1957 from 4 plots, 1 square meter in size, with a 0.3 meter buffer area. The surface 6 to 8 inches of soil was a silty clay, overlaying coarse sand. At times the water table was so close to the surface that the surface soil was thoroughly wet. Though these plots were observed frequently, no seedlings of any species became established.

Table 6. --Growth of tamarisk seedlings in varying conditions of temperature and soil moisture

Temperature and soil moisture conditions	Height of seedlings on--					
	July 29	Aug. 6	Aug. 13	Aug. 19	Aug. 27	Sept. 4
	Centimeters					
Laboratory:						
Watered 4 hours daily						
Distilled water	0.05	0.2	0.2	0.3	0.5	0.5
Tap water	.05	.2	.25	.3	.5	.5
Kept saturated						
Distilled water	.05	.2	.3	.4	.5	.7
Tap water	.05	.2	.3	.4	.5	.7
Greenhouse:						
Watered 4 hours daily						
Distilled water	.05	.1	.1	.1	Dead	--
Tap water	.05	.1	.1	.1	.15	Dead
Kept saturated						
Distilled water	.05	.5	.8	1.7	4.6	7.3
Tap water	.05	.4	.75	2.0	2.3	4.8

River Plots

An area was selected along a side channel of the Salt River to study establishment of tamarisk seedlings. In the spring of 1957, the channel area selected was covered with numerous tamarisk and scattered seepwillow seedlings less than 1 inch in height. These had probably originated from seed disseminated in the fall of 1956.

Six quadrats, 1 square meter in size, were established in a contour row on March 5, 1957, in the area of small tamarisk and seepwillow seedlings. Three belt transects (1 foot wide and about 50 feet long) were also extended across the side channel containing seedlings. On this date, 45 tamarisk and 12 seepwillow seedlings were counted on the 6 quadrats. On the 147 feet of transects, 116 tamarisk seedlings and 6 seepwillow seedlings were counted. Growth of both species was very slow in the first month but accelerated rapidly in the second (table 7).

Table 7. --Establishment and growth of seedlings on the Salt River

Seedling group and species	Established in receding flows--	Height of seedlings on--					Completely destroyed (1957)
		Mar. 5	Apr. 5	May 3	May 16	June 14	
		Centimeters					
1--Tamarisk	Fall 1956	1.4	3.1	15.7	--	0	June 4-5
Seepwillow		1.4	2.0	14.1	0	0	
2--Seepwillow	Mar. 20-24, 1957		.3	1.2	--	0	June 3-4
3--Tamarisk	Apr. 5-20, 1957			.1	1.0	0	May 25-June 2
4--Tamarisk	May 10-13, 1957				.1	0	May 20-24
5--Tamarisk	June 10-14, 1957					0.1	June 16-19

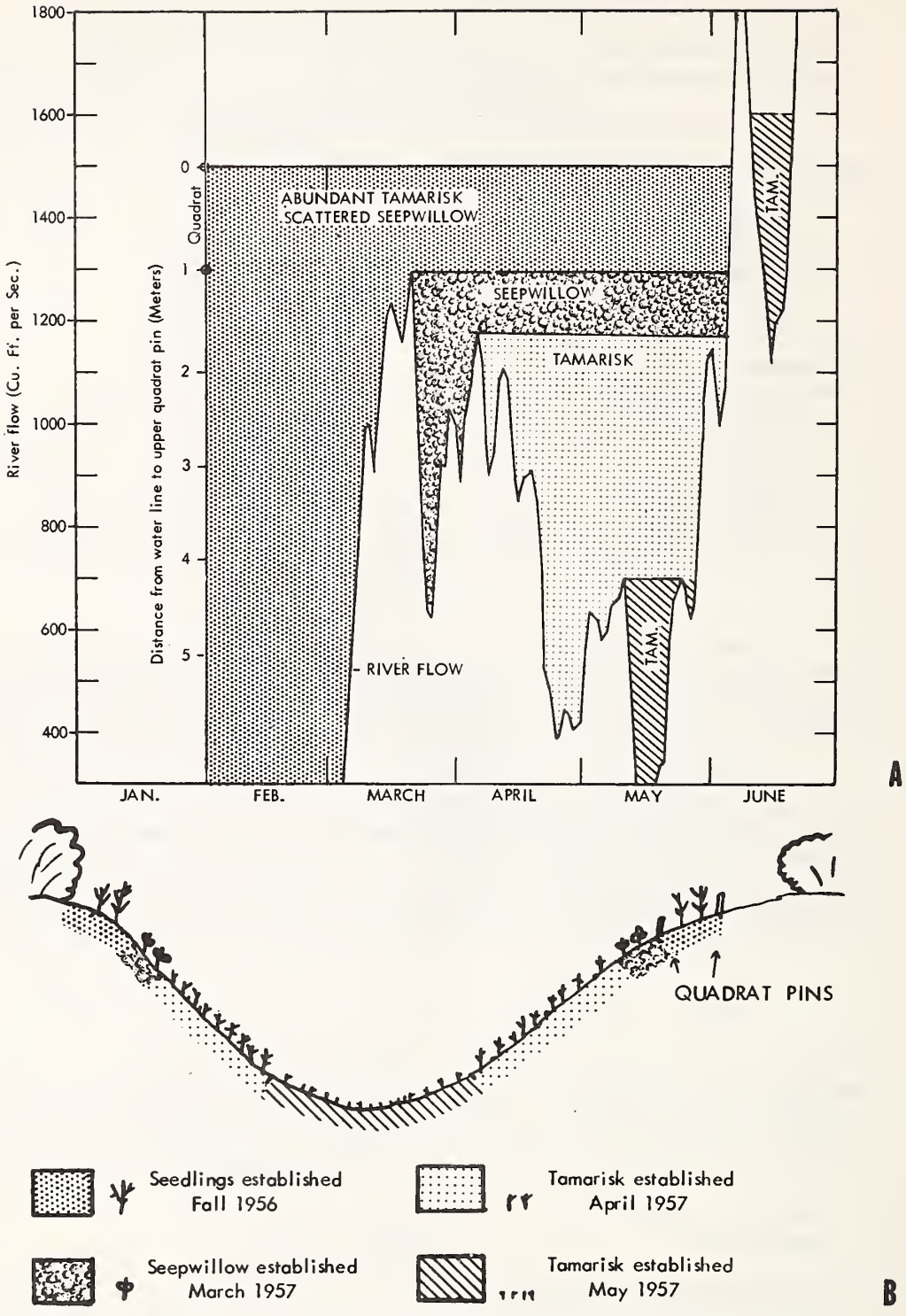

Figure 6. --A, Establishment of phreatophyte seedlings during receding flows of the Salt River in the spring of 1957. Each high flow (such as occurred in early March) removed all seedlings up to the high water mark. As the flow dropped, new seedlings became established. B, Profile of the same side channel to illustrate location of different-aged phreatophyte seedlings on May 16, 1957.

Flows of 1,300 cubic feet per second recorded at Granite Reef Dam have been observed to reach the lower quadrat pins, while flows of 1,500 cubic feet per second covered all of the quadrats (fig. 6A). When flow drops to about 600 second-feet, water ceases to move in the side channel.

During the spring of 1957, four high flow peaks removed seedlings principally by washing them away as the water rose, but left excellent germinating conditions as the water receded. The first peak, in March, reached 1,300 cubic feet per second; but the next two in April and May were lower in volume (fig. 6A). The fourth peak in June was high enough to remove all previous seedlings. After this high flow the river subsided for a few days before rising again to remain at a high level until fall.

During the first high flow in the middle of March the fall-established seedlings were removed from the lower part of the transects, leaving only those on quadrats. As this flow receded, an abundant stand of tiny seepwillow seedlings developed on the exposed end of the transects. No new tamarisk seedlings were found, perhaps because of the scarcity of fresh seed. None were observed flying until April 12.

The next high stage in early April removed these seepwillow seedlings, except for a thin band about 2 feet wide just below the quadrats. As this flow receded, a dense stand ranging from 20 to 100 tiny tamarisk seedlings per square foot developed on the exposed part of the transects.

The small peak of 700 cubic feet per second on May 10, removed the seedlings on the lower part of the channel. This period was one of maximum seed production and as this flow receded a lawnlike stand of tamarisk developed. Seeds were also germinating on the surface of the quiet pools and floating down the river. On May 16, four age groups of seedlings were growing in contour bands (fig. 6B). A few of the original seedlings established in the previous fall were growing on the quadrats, next a narrow band of seepwillow established in March, then a wide band of month-old tamarisk, and finally, the tiny seedlings in the bottom of the channel.

During the first weeks of June, the river rose much higher than at any previous period in 1957. On June 14, the flow had dropped and almost all previously established seedlings were gone. A few tamarisk were left but they were silt-covered and appeared dead. As before, newly germinated seedlings were observed in great numbers.

Several days later the flow came up again and stayed over the quadrats, with only two short breaks until September 20. As the high summer flow dropped, new seedlings again appeared. These were several inches in height by January 1958. A flood flow in March 1958 removed all of these seedlings. No seed were available for germination as this flow receded.

The cycle was renewed again as seed became available. On April 30, 1958, seed were germinating in a 3-foot band at high water line. All of these were destroyed as the flow came up in late May.

The river dropped quickly in September 1958, without subsequent higher flows. On January 19, 1959, the lower parts of the channel were covered with seepwillow seedlings (about 2 inches high) and many vigorous tamarisk seedlings (1 to 5 inches high). No seedlings were to be found as high up the banks as the quadrats. All were destroyed as the river flow increased for the irrigation season starting in March 1959.

Receding flows in periods of seed abundance provide optimum conditions for establishment of phreatophyte seedlings. Permanent survival is possible only in absence of subsequent high flows.

SUMMARY

Tamarisk produces seed abundantly over a long period (April to October). Seed remains viable for only a few weeks, especially at high temperature characteristic of Arizona deserts. Fresh seed germinates rapidly, generally in less than 24 hours. Germination is dependent upon saturated soils. Receding spring and summer flows are ideal for germination and seedling establishment. Seedlings grow slowly and are very sensitive to drying. In fact, survival is dependent upon saturated soils during the first 2 to 4 weeks of growth. Seedlings can be submerged several weeks or more, but when small they will be detached from the soil and float away if there is any appreciable current.

Seepwillow follows the same general pattern, but seeds remain viable for a longer time.

APPLICATION

Tamarisk spread along streams and rivers can be controlled by management of water flow. Along the Salt River, tamarisk seedlings become established on river banks during slowly receding flows that coincide with periods of high seed production. Rapidly receding flows are less favorable for seedling establishment, especially during hot weather when the banks dry out quickly.

Construction of levees to reduce the area flooded during high flows, and regulation of releases from reservoirs to avoid slowly decreasing flow during the seed-production season, may prevent tamarisk invasion of many areas.

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APPENDIX

Appendix table 1.--Collection dates and seed storage for seeds used in germination studies

Date	Tamarisk			Seepwillow		Broom baccharis	Fremont cottonwood	Arrowweed
	Laboratory	40°F.	Greenhouse	Laboratory	40°F.	Laboratory	Laboratory	Laboratory
1957								
March 11				x				
April 12	x			x				
May 10	x			x				
May 31	x			x				
June 6	x							
June 14	x			x				
June 28	x							
July 19	x							
July 26				x				
August 9	x	x						
August 19	x	x						
Sept. 3	x	x		x	x			
Sept. 23	x			x	x			
Sept. 30	x	x		x	x			
Oct. 7				x	x			
Oct. 21				x	x			
Nov. 18						x		
1958								
March 31				x			x	
April 7				x			x	
April 15				x			x	
April 21	x		x	x			x	
April 28	x		x	x				
May 5	x			x				
May 12	x		x	x				
May 19	x		x	x				
May 26	x		x	x				x
June 2	x		x					
June 9	x		x					
June 16	x		x					
June 23	x		x					
July 7								x
July 14	x		x					x
July 21	x		x					
July 28	x		x					
August 4	x		x					
August 18	x		x					
August 25	x		x					
Sept. 8	x		x	x				
Sept. 15	x		x	x				
Sept. 29				x				
Oct. 6	x		x	x				
Oct. 13				x				
Oct. 20				x				
Oct. 27				x				
Nov. 3				x				
Nov. 10				x				
Nov. 17						x		
Nov. 24						x		
Dec. 1						x		

Appendix table 2. --Viability of five-stamen tamarisk seed collected in 1957

Weeks	Lots collected											
	Apr. 12	May 10	May 31	June 6	June 14	June 28	July 19	Aug. 9	Aug. 19	Sept. 3	Sept. 23	Sept. 30
	Germination percent											
0	46	--	94	99	--	96	94	--	85	98	92	74
1	56	--	89	--	87	100	--	93	--	--	94	81
2	--	--	--	95	72	--	91	--	98	100	18	93
3	--	94	78	--	92	94	--	63	--	98	63	88
4	--	94	--	94	--	--	79	--	95	100	72	77
5	20	--	74	--	63	96	--	96	100	98	72	--
6	--	98	--	60	--	--	6	--	92	98	--	62
7	40	--	33	--	11	96	--	78	98	--	60	--
8	27	92	--	41	--	--	0	--	96	92	--	17
9	--	--	18	--	0	38	--	47	--	--	24	--
10-11	6	72	4	13	0	50	0	32	79	71	13	44
12-13	2	20	0	0	4	29	0	16	90	2	11	13
14-15	0	0	0	0	7	33	0	6	67	18	--	24
16-17	0	0	0	0	0	26	0	6	70	6	11	--
18-19	0	0	0	0	6	0	0	8	60	5	8	22
20-21	0	2	0	0	0	0	0	--	68	--	--	28
22-23	0	0	0	0	0	0	0	2	--	6	23	--
24-25	0	0	0	0	0	0	0	2	62	15	10	24
26-27	0	0	0	0	0	--	--	--	72	--	--	4
28-29	0	0	0	0	--	0	0	4	--	20	0	10
30-31	0	0	--	0	0	2	0	6	53	4	5	--
32-33	0	0	0		--	--	--	--	41	9	0	0
34-35	0				0	6	0	1	76	--	--	--
36-37	0				0	1	0	0	--	0	--	0
38-39	0				0	--	0	0	51	--	0	--
40-41					--	0	--	--	--	2	1	0
42-43					0	0	0	0	45	0	0	0
44-45					0	0	--	--	--	0	0	0
46-47						0	0	0	4	--	0	0
48-49						0	0	--	--	0	0	0
50-59						0	--	0	0	0	0	0
60-69						0	0	--	0	0	0	0
70-79								0	--	--	0	0
80-89								0	0	0	--	--
90-99								0	0	0	0	0

Appendix table 3.--Viability of five-stamen tamarisk seed collected in 1958

Weeks	Lots collected																		
	Apr. 21	Apr. 28	May 5	May 12	May 19	May 26	June 2	June 9	June 16	June 23	July 14	July 21	July 28	Aug. 4	Aug. 18	Aug. 25	Sept. 2	Sept. 15	Oct. 6
	Germination percent																		
0	100	51	90	95	87	96	94	88	86	91	96	88	92	96	94	92	96	100	100
1	57	81	90	96	99	97	84	94	75	95	91	85	98	99	90	91	78	100	98
2	53	61	90	98	86	96	88	78	58	89	86	89	98	98	100	94	80	93	62
3	61	72	97	91	73	94	86	73	61	88	90	67	89	96	100	89	94	97	96
4	67	90	85	95	90	94	41	73	69	85	67	82	64	93	89	84	56	80	88
5	82	51	93	89	83	77	62	68	72	70	66	54	71	89	98	64	60	61	79
6	63	50	80	81	47	80	63	83	52	74	40	44	46	76	78	61	42	68	67
7	56	70	62	66	67	76	39	72	40	29	26	42	4	61	39	59	32	46	60
8	59	40	48	71	76	65	36	34	33	11	31	9	6	84	12	45	30	30	59
9	31	32	38	64	40	71	43	6	13	0	0	4	15	34	25	40	15	27	38
10	26	36	41	21	49	25	8	5	0	0	20	2	0	58	6	28	21	45	42
11	7	9	20	40	28	17	2	0	0	9	21	4	4	53	4	19	20	19	38
12	8	3	15	3	17	0	0	0	0	0	4	2	11	28	0	11	21	6	52
13	0	0	0	0	2	0	0	0	0	0	4	0	2	11	5	8	6	6	46
14	0	0	0	0	0	0	0	0	0	0	0	1	0	32	2	39	6	16	37
15	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	7	2	8	37
16	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	2	8	7	25
17	0	0	0	0	0	0	0	0	--	0	0	0	0	7	0	5	8	6	38
18	0	0	0	0	0	0	0	--	--	2	2	2	0	4	0	2	5	6	25
19	0	0	0	0	0	0	--	--	--	0	0	0	0	6	0	3	4	5	54
20	0	0	0	0	0	--	--	--	--	0	0	0	0	0	4	2	4	3	24
21	0	0	0	0	--	--	--	--	0	0	0	0	0	11	0	2	10	4	18
22	0	0	0	--	--	--	--	0	--	0	0	0	0	4	0	2	7	14	15
23	2	0	--	--	--	--	0	--	--	0	0	0	0	0	0	9	10	1	24
24	0	--	--	--	--	0	--	--	--	0	0	0	0	2	3	5	5	7	14
25-29	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	4	5	2	15
30-34	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	3	--	--	--
35-39	0	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--	--	--	1
40-44	0	0	0	0	--	0	0	0	0	0	--	--	--	--	--	1	2	1	
45-49	0	0	0	0	0	--	--	--	--	--	--	0	0	8	0				
50-59	--	--	--	0	0	0	0	0	0	0	0								
60-69	0	0	0																

Appendix table 4. --Viability of seepwillow seed collected in 1957

Weeks	Lots collected										
	Mar. 11	Apr. 12	May 10	May 31	June 14	July 26	Sept. 3	Sept. 23	Sept. 30	Oct. 7	Oct. 21
	Germination percent										
0	--	26	--	12	--	--	11	78	15	14	28
1	--	8	--	2	--	8	--	11	14	12	13
2	--	--	--	--	--	--	--	39	0	12	--
3	--	--	0	--	--	--	0	11	9	7	20
4	52	--	2	--	--	--	2	--	6	--	--
5	0	0	--	--	--	18	--	26	--	23	67
6	--	--	--	--	--	--	4	--	12	--	--
7	--	15	--	--	0	--	--	21	--	83	67
8	--	18	--	--	--	--	12	--	27	--	--
9	2	--	--	--	--	--	--	81	--	76	18
10-11	17	--	--	--	0	0	10	60	83	20	--
12-13	5	--	--	0	--	--	62	29	17	--	33
14-15	--	--	--	--	--	--	98	--	32	12	18
16-17	--	--	0	--	--	--	0	33	--	19	--
18-19	--	--	--	--	--	--	14	33	11	--	24
20-21	--	0	--	--	--	--	--	--	8	16	10
22-23	--	--	--	--	--	--	0	20	--	7	--
24-25	2	--	--	--	--	--	6	17	2	--	8
26-27	--	--	--	--	--	--	--	--	2	16	37
28-29	--	--	--	--	--	--	0	17	24	17	22
30-31	--	--	--	--	--	--	0	48	--	12	--
32-33	--	--	--	--	--	--	18	13	4	--	--
34-35	--	--	--	--	--	--	--	--	--	--	--
36-37	--	--	--	--	--	--	0	--	5	--	29
38-39	--	--	--	--	--	--	--	1/ 18	9	0	10
40-41	--	--	--	--	--	--	--	9	17	10	--
42-43	--	--	--	--	--	--	8	6	6	--	34
44-45	--	--	--	--	--	--	--	18	18	30	--
46-47	--	--	--	--	--	--	15	39	18	--	0
48-49	--	--	--	--	--	--	--	9	21	17	--
50-54	--	--	--	--	--	--	7	32	12	--	--
55-59	--	--	--	--	--	--	0	--	--	--	--
60-69	--	--	--	--	--	--	--	19	2	8	9
70-79	--	--	--	--	--	--	0	7	7	3	0
80-89	--	--	--	--	--	--	2	--	--	--	0
90-99	--	--	--	--	--	--	0	2	2	2	

1/ Average of two lots.

Appendix table 5. --Viability of seepwillow seed collected in the spring of 1958

Weeks	Lots collected								
	Mar. 31	Apr. 7	Apr. 15	Apr. 21	Apr. 28	May 5	May 12	May 19	May 26
	Germination percent								
0	48	70	30	21	10	62	39	2	2
1	57	71	44	16	8	70	53	5	0
2	44	68	14	32	16	67	21	2	2
3	60	34	52	23	49	33	11	2	0
4	17	50	45	62	24	43	20	4	0
5	49	36	61	15	23	16	26	2	0
6	34	82	19	28	11	35	18	0	2
7	50	57	34	14	19	23	11	0	0
8	43	48	31	9	22	26	11	3	2
9	30	47	44	22	18	30	26	2	0
10	46	44	26	7	10	27	11	4	2
11	45	38	37	7	14	19	11	0	0
12	33	56	13	22	23	31	4	0	0
13	56	42	29	24	24	27	3	0	4
14	44	41	30	13	8	39	19	0	0
15	23	43	46	15	34	52	22	0	0
16	35	55	33	12	38	56	13	0	2
17	24	45	51	28	28	56	14	0	2
18	54	47	52	10	16	49	15	0	2
19	49	53	44	26	27	44	8	0	0
20	62	57	28	26	13	37	17	0	--
21	40	50	30	4	8	44	7	--	--
22	46	61	2	31	22	37	--	--	--
23	15	34	20	22	22	--	--	--	--
24	58	46	35	27	--	--	--	--	0
25	32	67	28	--	--	--	--	0	--
26	36	12	--	--	--	--	4	--	--
27	30	--	--	--	--	30	--	--	--
28	--	--	--	--	11	--	--	--	0
29	--	--	--	37	--	--	--	0	--
30-31	--	32	18	--	--	7	3	--	2
32-33	14	--	--	23	15	69	14	--	--
34-35	--	30	18	32	43	--	--	0	0
36-37	29	73	33	--	--	36	12	--	--
38-39	45	--	--	13	22	--	--	0	0
40-41	--	42	14	--	--	61	28	--	--
42-43	19	--	--	61	60	--	--	--	--
44-45	--	48	9	--	--	--	--	0	0
46-47	11	--	--	--	--	20	17	--	--
48-49	--	--	--	13	15	--	--	--	--
50-51	--	23	14	--	--	--	--	--	--
52-53	14	--	--	--	--	--	--	--	--
54-59	--	--	--	--	--	--	5	0	0
60-69	3	2	3	0	2	0			

Appendix table 6. --Viability of seepwillow seed collected in the fall of 1958

Weeks	Lots collected								
	Sept. 8	Sept. 15	Sept. 29	Oct. 6	Oct. 13	Oct. 20	Oct. 27	Nov. 3	Nov. 10
	Germination percent								
0	24	17	8	14	16	20	46	65	59
1	25	27	16	21	14	30	48	65	42
2	20	37	16	6	10	37	51	60	65
3	19	16	8	22	16	39	51	46	70
4	6	18	4	22	21	12	29	79	76
5	20	15	9	53	12	50	63	81	44
6	26	18	15	18	33	50	66	35	76
7	14	17	10	37	24	50	28	55	62
8	11	61	15	22	13	10	59	71	40
9	24	30	35	25	6	65	61	33	45
10	20	24	19	7	28	38	34	21	31
11	30	61	7	49	21	20	33	71	57
12	59	55	38	26	5	5	26	63	46
13	6	6	12	8	5	12	50	37	50
14	9	44	5	10	6	34	50	22	36
15	28	40	16	51	13	22	31	34	24
16	9	34	9	11	7	27	31	37	60
17	5	14	32	5	4	15	37	24	33
18	3	36	4	8	17	17	27	38	18
19	9	21	0	10	2	19	32	32	18
20	10	28	14	8	10	12	28	20	40
21	21	10	0	5	12	11	26	35	--
22	15	35	6	10	6	14	31	--	--
23	12	18	14	0	5	7	--	--	--
24	10	23	3	12	7	--	--	--	--
25	32	22	17	6	--	--	--	--	--
26	8	17	0	--	--	--	--	--	--
27	3	15	--	--	--	--	--	--	--
28	0	13	--	--	--	--	--	--	--
29	3	--	--	--	--	--	--	--	--
30-34	--	--	--	--	--	--	--	20	13
35-39	--	--	3	1	9	8	15		
40-49	6	7							

Appendix table 7. --Viability of broom baccharis collected in 1957 and 1958

Weeks	Lots collected				
	November 18, 1957 1/	November 18, 1957 1/	November 17, 1958	November 24, 1958	December 1, 1958
	Germination percent				
0	59	48	98	100	100
1	55	54	100	100	95
2	--	--	100	100	97
3	90	98	100	100	100
4	--	--	100	100	95
5	77	98	99	100	98
6	--	--	100	100	96
7	--	--	100	100	100
8	78	94	98	100	100
9	--	--	100	100	97
10	--	--	98	98	99
11	96	96	100	100	97
12	--	--	100	100	96
13	--	--	100	100	100
14	98	100	100	100	95
15	--	--	97	98	98
16	--	--	100	100	95
17	99	100	100	100	100
18	--	--	100	100	--
19	--	--	100	--	--
20-24	96	100	--	--	--
25-29	74	92	--	--	--
30-34	96	92	99	100	99
35-39	--	--			
40-44	77	73			
45-49	20	96			
50-59	92	90			
60-69	--	--			
70-79	91	63			
80-89	81	52			

1/ Lots collected on same day but at different locations.

Appendix table 8.--Viability of Fremont cottonwood and arrowweed seed collected in 1958

Weeks	Lots collected						
	Fremont cottonwood				Arrowweed		
	Mar. 31	Apr. 7	Apr. 14	Apr. 21	May 26	July 7	July 14
	Germination percent						
0	46	62	39	62	62	3	17
1	52	33	67	58	3	6	14
2	38	17	62	38	26	6	12
3	19	17	28	36	13	3	17
4	12	25	14	26	54	0	4
5	8	4	18	8	6	3	8
6	17	0	5	(1/)	2	3	6
7	0	0	0		34	10	15
8	0	0	0		24	12	0
9	0	0	0		38	0	0
10	0	0	0		20	0	0
11	0	0	0		20	11	12
12	0	0	0		25	5	7
13	0	0	0		47	8	--
14	0	0	--		65	--	--
15	0	--	--		18	--	--
16	--	--	--		28	--	--
17	--	--	--		44	--	10
18	--	--	0		29	5	--
19	--	0	--		34	--	--
20	0	--	--		--	--	--
21	--	--	--		--	--	5
22	--	--	--		--	3	--
23	--	--	--		--	--	3
24	--	--	--		23	7	--
25-29	0	0	0		35	14	0
30-34	--	--	--		21	62	5
35-39	0	0	0		72	12	6
40-44	--	--	--		39	--	--
45-49	--	--	--		--	--	--
50-54	0	0	0		--	25	8
55-59	--	--	--		44		
60-69	0	0	0				

1/ No more seed.

Appendix table 9. --Germination of tamarisk and seepwillow seeds stored at 40°F. Lots collected in 1957. (Compare with appendix tables 2 and 4 for germination of laboratory-stored seeds)

Weeks	Lots collected								
	Tamarisk				Seepwillow				
	Aug. 9	Aug. 19	Sept. 3	Sept. 30	Sept. 3	Sept. 23	Sept. 30	Oct. 7	Oct. 21
	Germination percent								
1	--	--	--	--	--	60	--	--	--
2	--	--	--	80	--	--	8	--	--
3	--	--	--	--	--	40	--	--	20
4	--	--	100	91	13	--	10	--	--
5	--	--	--	--	--	37	--	19	60
6	--	98	98	88	0	--	10	--	--
7	77	--	--	--	--	83	--	67	67
8	--	100	100	56	4	--	53	--	--
9	43	--	--	--	--	94	--	66	28
10-11	79	96	100	58	18	100	40	17	--
12-13	52	89	98	55	100	53	12	--	41
14-15	40	92	94	65	66	--	8	28	30
16-17	40	96	94	--	12	65	--	7	--
18-19	37	90	96	62	19	60	7	--	33
20-21	--	98	--	68	--	--	18	19	26
22-23	31	--	99	--	20	42	--	6	--
24-25	21	90	96	73	15	57	18	--	19
26-27	--	90	--	44	--	--	5	12	38
28-29	31	--	94	93	13	61	9	8	38
30-31	28	94	87	--	37	56	--	13	--
32-33	--	89	81	59	2	53	28	--	--
34-35	22	97	--	--	--	--	--	--	--
36-37	42	--	72	44	29	--	1	--	52
38-39	40	75	--	--	--	42	2	12	48
40-41	--	--	91	68	--	22	8	--	--
42-43	38	86	68	43	21	--	8	--	50
44-45	--	--	--	55	--	55	3	18	--
46-47	31	84	--	67	13	--	27	--	13
48-49	--	--	67	80	--	--	13	12	--
50-54	51	91	--	42	24	50	5	--	--
55-59	55	34	70	--	--	--	--	--	--
60-69	--	74	75	36	--	68	7	24	62
70-79	20	--	--	16	72	60	20	7	31
80-89	6	90	50	--	14	--	--	--	23
90-99	31	85	67	35	10	26	4	18	

Appendix table 10. --Germination of tamarisk seed stored under greenhouse conditions. Lots collected in 1958. (No germination in any test after 17 weeks).

Weeks	Lots collected														
	Apr. 21	Apr. 28	May 12	May 19	May 26	June 2	June 9	June 16	June 23	July 14	July 21	July 28	Aug. 4	Aug. 18	Aug. 25
	Germination percent														
0	--	72	95	89	85	71	76	--	90	91	78	90	100	97	95
1	49	66	100	93	78	91	90	80	87	89	82	95	97	96	98
2	71	71	97	74	77	77	63	31	77	88	83	60	96	84	92
3	85	76	84	76	63	55	11	33	59	70	83	26	82	88	34
4	65	87	62	48	7	43	62	8	66	64	24	3	79	17	26
5	82	25	9	8	36	19	20	41	45	26	0	0	87	3	11
6	6	0	0	0	0	6	15	2	11	7	0	3	68	0	0
7	11	0	0	0	0	6	7	10	2	3	0	0	17	0	0
8	0	0	0	0	0	4	0	0	0	0	0	0	11	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
11	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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